LIBRARY
OF THE
UNIVERSITY
OF ILLINOIS
630.7
Il6b
no. 676-700

AGRICULTURE

NOTICE: **Return or renew all Library Materials! The *Minimum* Fee for each Lost Book is $50.00.**

The person charging this material is responsible for its return to the library from which it was withdrawn on or before the **Latest Date** stamped below.

Theft, mutilation, and underlining of books are reasons for disciplinary action and may result in dismissal from the University.
To renew call Telephone Center, 333-8400

UNIVERSITY OF ILLINOIS LIBRARY AT URBANA-CHAMPAIGN

L161—O-1096

30.7
Il6b
Agri

THE ECONOMIC VALUE OF MANURE FROM CONFINEMENT FINISHING OF HOGS

Roy N. Van Arsdall

LIBRARY OF ILLINOIS
JUN 28 1962
LIBRARY

Bulletin 687

UNIVERSITY OF ILLINOIS · AGRICULTURAL EXPERIMENT STATION

CONTENTS

This bulletin was prepared by ROY N. VAN ARSDALL, Agricultural Economist, Economic Research Service, United States Department of Agriculture, and Professor of Agricultural Economics, University of Illinois. Published in cooperation with the Farm Economics Division, Economic Research Service, United States Department of Agriculture.

Urbana, Illinois May, 1962

Publications in the Bulletin series report the results of investigations made or sponsored by the Experiment Station

MANURE HAS BEEN CALLED the most valuable byproduct of Illinois agriculture.[1] Approximately 13 million hogs are produced on Illinois farms each year. The manure byproduct from this branch of the state's livestock industry yields plant nutrients that would cost many millions of dollars if purchased at prevailing prices for chemical fertilizers.

Collection and use of this manure, however, constitute an increasingly heavy expense for the farmer. Probably as much as half of all hog manure is now dropped at the farmstead, and the trend toward confinement raising of hogs will increase this amount still further. Many farmers who change from pasture to confinement production of hogs to eliminate such jobs as fence building, and hauling feed and water, soon find that the manure-handling chore more than offsets the labor saved in other parts of the operation.

Manure handling in confinement systems has been taking an average of three-fourths of the total labor input used to grow and finish hogs. Loaders, spreaders, tractors, and other manure-handling equipment, and the bedding used to keep the hogs clean and comfortable and to conserve the liquid in the manure have added to production costs.

The handling of manure has always been accepted as a necessary and unavoidable cost of livestock production. Because the manure had to be loaded on a vehicle and hauled from the premises in any case, the profitability of spreading it on cropland was not questioned. The fertility value thus obtained was simply a bonus return to the enterprise.

The valuable plant nutrients in manure are perhaps present in greater quantity now than formerly because of the increased use of high-protein feeds. Spreading solid manure on cropland rather than dumping it in a disposal area is still a profitable practice because there is little difference between spreading and disposal costs.

Technological improvements in housing and equipment, however, have changed hog production methods, and also the cost situation. In a properly designed building, hogs can do without bedding, and water can be used to clean the floors, converting the manure into a fluid that can be removed with pumps or by gravity. Under this system it is easy and relatively inexpensive to discard the manure in a lagoon or other kind of disposal system.

These new developments raised the question of whether the value of liquid hog manure justifies the added expense of providing storage for it and applying it to cropland, or whether it is more economical to

[1] Thompson, W. N., Manure — Multimillion Dollar Byproduct. Farm Mgt. Letter 41, Agr. Econ. Dept., Univ. Ill., July, 1953.

buy chemical fertilizers and consider liquid manure a waste product to be removed in the least expensive way.

Method of Study

A study to provide information for an economic evaluation of confinement systems of hog production on Illinois farms was initiated by agricultural economists of the Farm Economics Division, Economic Research Service, U. S. Department of Agriculture, and the Illinois Agricultural Experiment Station. The study covered 72 farms on which hogs were grown and finished in confinement during 1959 and 1960. Operators of these farms furnished information by answering questions, permitting researchers to observe their operations, and keeping production and labor records.

The problem of manure handling was selected for special consideration because it is a laborious, disagreeable, and time-consuming job that has probably caused more concern than any other aspect of confinement raising of hogs. Three methods of handling hog manure were studied: (1) the use of straw or other dry bedding material and the subsequent handling of manure as a solid; (2) the confinement of hogs on a bare concrete floor and the handling of manure as a liquid, to be stored and later applied to cropland; (3) the handling of manure as a liquid to be discarded in a manure lagoon. The chief concern of this study was to compare costs and benefits of methods (2) and (3) for enterprises ranging in capacity from 250 to 2,500 hogs in terms of annual production.

Data from the records of the 1959-1960 hog enterprises are used throughout this bulletin to describe systems of handling manure, and as a partial basis for estimating or calculating the capital requirements and annual costs cited in the tables. Values for the soil fertility elements in hog manure and the probable fertility losses in handling, storage, and application to cropland were obtained from research data as noted.

Built-up Litter Systems

Most confinement producers have followed the conventional method of bedding their buildings with straw or similar material and periodically removing the bedding and manure in solid form with tractor-powered equipment. Previous experience with pasture systems of producing hogs, the use of bedding with other classes of livestock, and the availability of tractor-powered loaders, scrapers, and spreaders led farmers to continue with conventional methods. Also, it was seldom possible to provide the drainage necessary for successful operation of a liquid system in buildings converted into finishing barns from other uses. Even on farms with new buildings designed for handling liquid manure, farmers have sometimes been forced to revert to handling manure as a solid during part of the year because of freezing temperatures and inadequate drainage.

All farmers in the study who handled manure as a solid used tractor-mounted loaders for putting manure into spreaders. Only a third of the operators, however, were able to clean their facilities entirely with tractor equipment. A similar proportion relied about equally on hand labor and tractor-powered equipment. The remaining third did all of their cleaning by hand because their buildings could not be entered with a tractor. Most of the units in the last group housed fewer than 200 head of hogs.

As a year-round average, the built-up litter systems were cleaned once a week. Some operators, however, simply added straw two or three times a week, or as needed, to keep the bedded area clean, and removed manure from the buildings no oftener than once a month.

Systems with built-up litter were usually cleaned only when the manure could be spread directly on the fields. Sometimes, however, the manure was stored in piles to await spreading under suitable conditions. A slab or wide gutter outside the lot fence was the extent of storage structures and none of the storage areas was roofed. Losses, inadequate drainage, odors, and flies usually made such storage unsatisfactory.

Liquid-Manure Systems

Systems designed for handling manure as a liquid are drawing increasing interest from hog producers in the Midwest. A few of the early users of such systems disposed of the manure by flushing it into some type of drainage system. Most producers, however, built storage tanks and arranged for spreading the liquid manure on cropland.

Unlike the common European practice of providing storage for the highly concentrated urine only, the practice of midwestern hog producers is to store and handle all of the hog excrement plus all water used in the cleaning operation. The problem of handling such large volumes of liquid has aroused interest in the lagoon system in which the manure is flushed into a lagoon or pond, where it is stabilized by bacterial action. This disposal method wastes the fertility value of the manure, but saves considerable labor and equipment expense.

Cleaning methods. Units for handling manure as a liquid are cleaned either with hand scrapers or with water under pressures of 100 to 120 pounds per square inch. In the manual systems, water is used as a carrying agent to move the manure to storage or a disposal area. Units equipped with high-pressure water systems use water both for cleaning the floors and for carrying away the manure. The operator works from a center or side alley and flushes the manure to a gutter on the opposite side of the pen.

An experimental unit on the Moorman Swine Breeding Research Farm at the University of Illinois holds promise for reducing the labor of manure removal. A growing-finishing building has been constructed with a slotted (or slatted) floor so that the excrement passes through the slots and is pooled in water beneath the building and periodically flushed into a lagoon for disposal. It is expected that the slotted floor will be virtually self-cleaning.[1] Researchers hope also that the contents of the holding pool can be flushed into the lagoon without difficulty the year around or, if necessary, retained beneath the building for extended periods without ill effects.

Frequency of cleaning. Farmers who do not use bedding in their growing-finishing facilities usually consider daily cleaning a necessity. A few producers scrape or flush their floors twice daily, while others clean them as infrequently as once each week. Floors are usually cleaned more often when the hogs are large, and during wet, cool weather.

Research to date has not provided an answer to the question of what constitutes optimum cleanliness in hog buildings. Among the factors to be considered are the effect of manure accumulation on the animals, and the attitude of the operator. If manure accumulation does not constitute a costly stress on the animals, then fewer cleanings would reduce unit costs. The farmer's satisfaction in having a neat, clean operation, and the desire to forestall offensive odors from manure accumulation have so far tended to encourage the practice of daily cleaning.

Storage facilities. Tanks for conserving liquid manure for use on cropland are commonly constructed of either concrete block or cast-in-place concrete. Most are built on the farm, but prefabricated tanks are sometimes used in small operations. Tanks for storing liquid

[1] Spillman, C. K., "Slatted Floors for Raising Swine," *Illinois Research,* Vol. 3, No. 3, Ill. Agr. Exp. Sta., 1961.

manure should be designed to handle 2 gallons of liquid per hog per day for at least 2 weeks if floors are washed with water.[1]

Capacity of the tanks on the farms in the study ranged from less than 2-day up to 4-week accumulations (Table 1). Differences in cleaning practices and amount of water used account for part of the variation in capacity. For the most part, tank capacities approached

Table 1. — Characteristics of Facilities for Storing Hog Manure as a Liquid in Confinement Finishing Systems

Farm No.	Type of layout	Producers' estimates				Actual tank capacity at 2 gallons per hog per day
		Maximum number of hogs	Tank capacity in terms of volume	Tank capacity in terms of time	Tank capacity per hog per day[a]	
			gallons	*days*	*gallons*	*days*
1..........	roofed	600	10,000	30	.56	8.3
2..........	roofed	200	3,200	21	.76	8.0
3..........	roofed	200	3,400	7	2.43	8.5
4..........	roofed	200	4,000	14	1.43	10.0
5[b].........	roofed	500	25,000	30	1.67	25.0
6..........	open[c]	225	1,500	3	2.22	3.3
7..........	open[c]	420	12,000	12	2.38	14.3
8..........	open[c]	400	9,000	14	1.61	11.2
9..........	open[c]	850	3,000	7	.50	1.8
10..........	open[d]	400	3,600	([e])	([e])	4.5

[a] Based on maximum number of hogs that could be put into the buildings as estimated by the producer.
[b] This unit was cleaned with water under high pressure. All other producers scraped their floors by hand, and used water to flush the manure into storage but not to clean the floors.
[c] Roof guttered or sloping away from the open lot, thus not draining into the storage tank.
[d] Roof drained into the storage tank.
[e] No estimate.

the recommended levels on the basis of length of storage period estimated by the farmer, but few were large enough to hold a minimum 2-week accumulation based on a daily rate of 2 gallons per hog with the house stocked to capacity. Some tanks had as little as one-fourth the storage space necessary to handle a liquid system. Overflow from storage tanks was frequent on these farms, and it was particularly serious when barn roofs and open lots drained into them.

Pumping from storage. Electric- and gasoline-powered diaphragm pumps, tractor-powered vacuum pumps, and electrically driven augers were used to remove liquid manure from storage on the farms in the

[1] Jedele, D. G., and Hansen, E. L., Handling Hog Manure as a Liquid, Ill. Agr. Ext. Serv. Cir. 820, April, 1960.

study. The diaphragm and vacuum pumps normally produced at a higher rate than the auger units, but they required relatively large power units, and initial costs were high — usually from $350 to $500 excluding the power unit.

The typical system was equipped with an auger to move the liquid from storage to an applicator tank. Four-inch enclosed augers, 16 to 20 feet long, powered by a ½- to 1-horsepower electric motor, were used by most producers. These units cost $100 to $150 depending upon motor size and quality of the auger.

Chief difficulties encountered by the early users of auger pumps were low rate of output, and rapid deterioration of the unit. Underpowered augers often required as much as 1 hour to move 500 gallons of liquid from storage to the applicator tank, causing considerable waste of labor on many farms.

Tests conducted at the University of Illinois indicate that a 4-inch auger will pump about 50 gallons per minute when operated at 1,600 r.p.m. using a 1-horsepower motor.[1] This rate is sufficient to fill the usual applicator tank in a reasonable amount of time.

Liquid applicators. There has been a lack of effective equipment designed specifically for spreading liquid manure onto cropland. Because of the relatively small number of potential customers, the main-line equipment manufacturers were not producing liquid spreaders in quantity during the period of study. Most farmers were — and still are — using custom-made units mounted on a running gear and pulled by a tractor, or mounted permanently on a truck frame. Attachments usually consist of a fan-shaped or rotating spreader, and an agitator to prevent the solids from settling.

Tank sizes used by most producers range from 500 to 1,000 gallons. Economy of travel encourages farmers to use large tanks, but weight places the practical limit at about 1,000-gallon capacity for most situations. Cost ranges up to $1,000 for a 1,000-gallon unit. Mounting the tank on a truck frame instead of using tractor power adds considerably to the initial cost, but some farmers prefer this method in order to free the tractor for other jobs.

Some commercial equipment for application of liquid manure is now available at about the same cost as custom-built units.

Frequency of hauling. On the study farms the frequency of hauling varied from almost once a day for operators with small storage

[1] Illinois Circular 820.

tanks, to once a month at the other extreme. Storage capacity and volume of water moving into storage were the chief factors affecting frequency of hauling. Condition of the fields, availability of a place to spread the liquid, and demands of other jobs were other factors.

Disadvantages of liquid-manure systems. None of the producers included in the study was completely satisfied with the liquid cleaning system he was using. Frequent criticisms included the large amount of time and hand labor necessary to scrape or hose down the buildings, and the time and expense involved in hauling the huge quantities of liquid accumulated in water-cleaned systems. The hogs were inconsistent in their use of the dunging alley, intensifying the cleaning problem so that building designs did not function as expected. In the open-front buildings, freezing during winter compelled some operators to abandon the liquid system temporarily and to use bedding to protect the hogs. Such combination systems created operational problems. The need to haul liquid regularly and frequently sometimes forced farmers to travel over wet fields or, particularly during the cropgrowing season, to dump manure on wasteland. During the summer, odors and flies constituted serious nuisances on many farms.

Initial and Annual Costs of Liquid-Manure Systems

There is some variation in the cost of systems designed to store liquid manure and preserve its fertility value for use on cropland. Factors that influence cost of facilities include locality, type of materials, kind of equipment, and the farmer's ability for carpentry and shopwork. Key factors in establishing operating costs include availability of tractor power for hauling the liquid, location of areas on which the liquid is to be spread, and value placed on the operator's time.

Cost of storage facilities. Storage is of first concern in planning a system when the liquid manure is to be used on the land. It is advisable to plan for holding at least 2 weeks' production from the full capacity of the system. A good rule-of-thumb for determining the necessary volume of storage facilities is to multiply the number of hogs at maximum capacity times 2 gallons of liquid times days of storage desired. A unit designed for 125 hogs, therefore, would require a 3,500-gallon storage tank to handle a 2-week accumulation. Storage space for 35,000 gallons would be needed for an operation handling 1,250 hogs at one time.

Storage tanks can be constructed from several materials, but cast-in-place concrete or core-filled concrete blocks are best for most areas

Table 2. — Calculated Initial and Annual Cost of Concrete Tanks for Storing Liquid Hog Manure

Size of tank[a]	Capacity in gallons[b]	First cost[c]	Annual cost[d]
10′ x 4′	1,500	$ 276	$ 28
10′ x 6′	2,250	324	32
10′ x 8′	3,000	394	39
20′ x 4′	3,000	462	46
20′ x 6′	4,500	576	58
20′ x 8′	6,000	676	68
30′ x 4′	4,500	668	67
30′ x 6′	6,750	812	81
30′ x 8′	9,000	962	96
40′ x 4′	6,000	876	88
40′ x 6′	9,000	1,062	106
40′ x 8′	12,000	$1,244	$124

[a] Inside dimensions.
[b] Assuming the level of liquid to be 1 foot below the top of 6-foot-deep tank.
[c] Tank is constructed of cast-in-place concrete walls and floor, 6 inches thick, reinforced with 6-by-6-inch welded-wire mesh. Top is wood frame covered with sheet metal. Material prices are typical for central Illinois in 1960. Labor for construction is charged at 100 percent of material cost. Concrete-block tanks, core-filled and reinforced, can be constructed at similar costs. (For construction details see Illinois Circular 820.)
[d] Includes 5 percent for depreciation and 5 percent for interest, maintenance, and taxes.

in Illinois. Calculated initial costs of tanks per 1,000 gallons of capacity range from $104 for 12,000-gallon tanks to $184 for 1,500-gallon tanks (Table 2). These costs include a labor charge equal to 100 percent of the material cost. One or more of these tanks, as required to supply needed capacity, form the basis of the storage-investment estimates appearing in Table 3.

Some economy is achieved with the larger storage tanks. Size of operation is even more important, however, in cutting unit investments in pumping and spreading equipment because essentially the same equipment is needed for handling liquid manure whether the operation is small or large. Estimates indicate that a tenfold increase in output necessitates less than a threefold increase in investment for manure storage and handling facilities (Table 3).

Annual calculated costs of storing, pumping, hauling, and spreading liquid manure range from about $320 for 250 hogs to $1,550 for 2,500 hogs (Table 4). The unit cost advantage remains with the larger operations, but it is not so pronounced as with investments because labor and tractor inputs comprise a substantial part of the total annual cost. These two inputs, which account for 30 percent of the total cost for 250 hogs and 60 percent of the total cost for 2,500 hogs, cost about the same per unit regardless of size of operation. Producers with large

Table 3. — Calculated Capital Outlay for New Facilities for Storing, Pumping, Hauling, and Spreading Liquid Hog Manure

Hogs produced annually	Investments			
	Storage tank(s)	Auger pump[a]	Applicator tank[b]	Total
250	$ 460	$130	$1,000	$1,590
500	842	130	1,000	1,972
750	1,342	130	1,000	2,472
1,000	1,684	130	1,000	2,814
1,250	1,872	130	1,000	3,002
1,500	2,206	130	1,000	3,336
2,000	2,994	130	1,000	4,124
2,500	$3,626	$130	$1,000	$4,756

[a] A heavy-duty 4-inch by 20-foot auger with 1-horsepower motor.
[b] A 1,000-gallon tank with agitator and fan spreader mounted on four-wheel running gear. Assuming availability of a tractor to pull applicator tank. In large operations an additional tractor may be required.

operations, however, may experience a considerable increase in unit labor and tractor costs if they are forced to go farther and farther from the production center to find areas on which to apply the manure profitably. Thus as size of operation increases, the cost estimates in Table 4 actually become increasingly conservative.

Cost of disposal lagoons. The task of getting liquid manure from feedlot to cropland has caused increased interest in lagoons for manure

Table 4. — Calculated Annual Labor, Equipment, and Structure Costs for Storing, Pumping, Hauling, and Spreading Liquid Hog Manure

Hogs produced annually	Storage tank[a]	Auger pump[b]	Applicator tank[c]	Labor[d]		Tractor[e]		Total annual costs
				Hours	Cost	Hours	Cost	
250	$ 46	$31	$147	46	$ 55	34	$ 40	$319
500	84	32	154	90	108	68	80	458
750	134	34	161	135	162	101	118	609
1,000	168	35	168	181	217	135	158	746
1,250	187	36	174	226	271	169	198	866
1,500	221	38	181	271	325	202	236	1,001
2,000	299	41	195	362	434	270	316	1,285
2,500	$363	$44	$208	452	$542	338	$395	$1,552

[a] Ten percent of initial cost to cover annual costs of depreciation, interest, taxes, insurance, maintenance, and repairs.
[b] A 5-year or 1,500-hour life with lifetime repairs equaling 50 percent of initial cost of machine; electricity use charged at 2 cents per horsepower hour.
[c] A 5-year life with lifetime repairs equalling 30 percent of initial cost.
[d] Twenty minutes to pump, 15 minutes to spread, and 5 minutes for preparatory work in handling a 1,000-gallon tank of manure. Wage rate, $1.20 per hour.
[e] Tractor time is 30 minutes per load at $1.17 per hour, the 1958 average cost of using 25- to 36-horsepower tractors for 500 or more hours per year. Agr. Econ. Res. Rep. 32, Detailed Cost Report for Heavy Till Soils, Central Illinois, 1958. Agr. Econ. Dept., Univ. of Ill.

disposal. Under this system, manure is flushed from the buildings and lots into a lagoon or pond where it is stabilized by bacterial action. Cities and factories have used this method of waste disposal for many years, but only limited data are available concerning the use of lagoons in animal production.

Early attempts at using lagoons for handling liquid hog manure have been encouraging. Experience shows that a lagoon that is constructed, used, and maintained according to recommended procedures,[1] remains serviceable for at least 5 years. A more exact determination of useful life and of the costs of rejuvenating a lagoon will require study of the rate of sediment accumulation, and longer and more extensive experience under operating conditions.

Experimental lagoons at the University of Illinois swine farm are designed to provide from 20 to 60 square feet of water surface area per hog. These trials are incomplete, but 20 square feet are presently considered adequate. On this basis, the land area needed for a lagoon is rather small, amounting to less than 1 acre for an operation producing 2,500 hogs per year (Table 5).

Table 5. — Calculated Size of Lagoon for Handling Liquid Manure for Selected Sizes of Hog Operations

Hogs produced		Water area needed[a]	Fencing needed[b]
Each year	Maximum on hand		
		square feet	*feet*
250	125	2,500	320
500	250	5,000	404
750	375	7,500	468
1,000	500	10,000	520
1,250	625	12,500	568
1,500	750	15,000	608
2,000	1,000	20,000	684
2,500	1,250	25,000	752

[a] Based on 20 square feet per head and the maximum expected to be on hand at one time.
[b] Lagoon is assumed to be square with the fence 15 feet from the shoreline.

The cost of building a lagoon is affected greatly by its site and by custom rates for earth moving, and the like. The average farmer can expect to invest from $30 to $80 per 100 hogs produced annually, depending upon size of operation, if he hires all of the work done (Table 6).

[1] For specific recommendations, see Illinois Circular 820.

Table 6. — Calculated Initial and Annual Costs of Liquid-Manure Lagoons to Service Selected Sizes of Hog Operations

Hogs produced annually	Earth moving[a]	Fencing[b]	Tile[c]	Total invest-ment	Total annual costs[d]
250	$ 56	$27	$120	$203	$ 51
500	111	36	120	267	67
750	166	43	120	329	82
1,000	222	48	120	390	98
1,250	278	53	120	451	113
1,500	333	58	120	511	128
2,000	444	66	120	630	158
2,500	$555	$72	$120	$747	$187

[a] A 45-horsepower bulldozer moving earth an average of 100 feet at a rate of 50 cubic yards per hour. Lagoon averages 2 feet of earth removal. Fifteen dollars per hour for an operator and machine.
[b] A 3-strand barbed-wire and steel-post fence around the lagoon 15 feet from the shoreline.
[c] An 8-inch tile to carry liquid from buildings to the lagoon 100 feet away.
[d] Allowing 20 percent for depreciation and 5 percent for maintenance and interest on investment.

Value of Liquid Hog Manure

Moving liquid manure from buildings and lots is essentially the same operation whether the liquid is stored for later use on cropland or flushed into a lagoon for disposal. Thus if profit is the chief objective in selecting a system, the fertility value of the manure saved must more than offset the added costs of a storage and handling system. Computations based on standard data show that the annual cost of storing and spreading liquid manure in a 250-hog operation is $268 greater than the annual cost of using a lagoon (Table 7). The difference

Table 7. — Annual Cost of Storing and Spreading Liquid Manure Compared With Disposal in a Liquid-Manure Lagoon

Hogs produced annually	Annual costs		
	Storage and spreading[a]	Lagoon system[b]	Additional cost of storage and spreading
250	$ 319	$ 51	$ 268
500	458	67	391
750	609	82	527
1,000	746	98	648
1,250	866	113	753
1,500	1,001	128	873
2,000	1,285	158	1,127
2,500	$1,552	$187	$1,365

[a] Data from Table 4.
[b] Data from Table 6.

increases to $1,365 on farms that have an output of 2,500 hogs a year. These costs must be equaled or exceeded by the fertility value of liquid manure if a storage and spreading system is to be more profitable than a lagoon system.

Corn and soybean meal, the main constituents of growing-finishing rations for hogs in the Midwest, contain quantities of nitrogen, phosphorus, and potassium — the chief elements needed for plant growth (Table 8). Seventy-two to 90 percent of each of these elements passes through hogs into the excreta (Table 9). At this rate, the value of the soil fertility elements excreted by one hog while growing from 50 to 220 pounds averages $1.62 based on 1960 prices for the same elements in straight commercial fertilizer materials. Total value could run as

Table 8. — Percentage of Specified Soil Fertility Elements in Selected Feedstuffs[a]

Feedstuff	Content of fertility elements				
	Nitrogen	Phosphorus	P_2O_5	Potassium	K_2O
			percent		
Corn, dent No. 2	1.39	0.27	0.62	0.29	0.35
Soybean meal, solvent, 44-percent-protein guarantee	7.31	0.63	1.44	1.92	2.31

[a] Morrison, F. B., Feeds and Feeding, 22nd ed., 1956.

Table 9. — Amount and Value of the Chief Soil Fertility Elements Present In and Excreted From a Swine Growing Ration[a]

	Feed	Fertility elements		
		N	P_2O_5	K_2O
Corn, lb.	512	7.12	3.17	1.79
Soybean meal, lb.	83	6.07	1.20	1.92
Total	595	13.19	4.37	3.71
Percent excreted[b]	...	72	83	90
Pounds excreted	...	9.50	3.63	3.34
Value per pound[c]	...	$0.12	$0.09	$0.044
Total value of fertility elements excreted	...	$1.14	$0.33	$0.15

[a] The rate of feed conversion is assumed to be 3.5 pounds of feed per pound of gain. The ration, for growing a pig from 50 to 220 pounds, is composed of 8-percent-protein corn and 44-percent-protein soybean meal, plus necessary fortifying agents. The ration averages 13 percent protein over the feeding period.

[b] Salter, R. M., and Schollenberger, C. J., op. cit., p. 8.

[c] Typical 1960 Illinois prices for commercially prepared N in ammonium nitrate, P_2O_5 in super phosphate, and K_2O in muriate of potash. See Agricultural Prices, Agr. Mkt. Ser., USDA, Sept., 1960.

much as one-fourth greater if based on the cost of the ingredients in higher-priced mixed fertilizers. Quantities of organic matter in liquid manure are considered too small to be significant.

Losses in fertility value. Manure loses part of its fertility value while lying on the feeding floor and in storage.[1] The amount of loss depends upon many factors, chief of which are temperature, amount of surface exposed to air, delay in removal to storage, method of storage, and length of storage period.

Nitrogen is both the most valuable and most unstable of the soil fertility elements in manure. In the early period following excretion, manure is quite rapidly attacked by bacterial action. Changes are especially rapid in the soluble nitrogenous compounds such as urea. Unless liquid manure is quickly moved into storage that provides anaerobic conditions, loss of nitrogen by volatilization of ammonia and evolution of nitrogen gas is quite high. With the best handling facilities, researchers have been able to reduce losses under farm experimental conditions to about one-sixth of the nitrogen in the manure. Further losses can be largely avoided by immediate storage of manure under strictly anaerobic conditions such as are provided by a tightly covered tank and a thin film of tar or oil floating on the surface of the liquid.[2] However, the nitrogen loss may easily amount to 50 percent or more under typical farm practices of storing manure in open vats as is now done on many farms in Illinois.[3]

Loss of fertility value also occurs when manure is spread at other than optimum times and on crops other than those that can best use the fertility constituents. The ideal time to spread manure on the land is in the spring or fall, immediately before plowing. Even under optimum conditions, the nitrogen loss may be heavy. Plots under continuous wheat production at Rothamsted, England, received 14 tons

[1] Salter, R. M., and Schollenberger, C. J., Farm Manures, Ohio Agr. Exp. Sta. Bul. 605, Sept., 1939.

[2] Ibid., pp. 31-32.

[3] For comprehensive discussions of the fertility value of manures, see Hall, A. D., Fertilizers and Manures, 3rd ed., John Murray, London, 1929; Morrison, F. B., op. cit., Chap. 24; Smith, A. M., Manures and Fertilizers, T. Nelson and Sons, Ltd., London, 1952. For analyses of soil fertility elements in solid hog manure produced under specified conditions, see Bauman, R. H., and Fitzpatrick, J. M., Production, Composition, and Costs of Handling Farm Manures on Indiana Farms, Purdue Agr. Exp. Sta., July, 1953. Generally, the fertility values reported by Bauman and Fitzpatrick range from $1.90 to $3.08 per ton of manure based on 1960 prices.

of farmyard manure per acre per year over a 50-year period. Only 26 percent of the nitrogen in the manure was recovered by the crops. Seventeen percent was lost in handling and storage of the manure and 57 percent was apparently lost in the field, as it could be accounted for neither in the crops nor in the soil.[1]

Tests on the Danish State Experimental Farms show that manure loses nearly half of its yield-increasing potential after lying on the land for only four days before being plowed under, as compared with immediate plowdown.[2]

Availability of fertility elements. Evidence also suggests that, because of variation in availability, a pound of organic nitrogen as found in manure may not be worth as much for some purposes as a pound of inorganic nitrogen in mineral fertilizer. While nitrogen in urine is as readily available as that of such mineral fertilizers as sulfate of ammonia or nitrate of soda, the nitrogen of dung is of very low grade.[3] Much of the nitrogen in dung and in bedding materials, which are sometimes used, is in forms that are either unavailable to crops or only slowly available, sometimes requiring years before being totally converted into available forms. Such slow release of nitrogen is advantageous for some crops, but others may suffer by not being able to get nitrogen when it is needed. Test plots in England showed that rapidly growing mangolds did not get as much nitrogen from farmyard manure containing 200 pounds of nitrogen as they did from nitrate of soda containing 86 pounds of nitrogen.[4] On the other hand, the phosphoric acid and potash in manures are practically equal in availability to the same elements in mineral fertilizers.[5]

In year-round hog confinement operations, manure needs to be removed regularly and frequently. Since applications must often be made at inappropriate times in the crop cycle, manure must sometimes be spread on land devoted to low-value crops, or even on wasteland. Corn, corn, small grain, meadow — a four-year rotation common on livestock farms in the corn belt — provides for optimum application of liquid manure for only a limited period of time during the year. Little more than half of the manure can be placed on ground to be used for second-year corn. Most of the remainder must be spread on old rota-

[1] Hall, A. D., op. cit.
[2] Salter, R. M., and Schollenberger, C. J., op. cit., p. 35.
[3] Ibid., p. 41.
[4] Hall, A. D., op. cit.
[5] Salter, R. M., and Schollenberger, C. J., op. cit., pp. 42-43.

tion meadow and new seeding which benefit little, if at all, from the application of manure. The carryover value of the nitrogen in such applications for the first-year crop is unknown.

Management practices and facilities for storing and handling liquid hog manure differ greatly among farms. Research evidence suggests, however, that even under the most favorable conditions the loss of fertility elements will amount to at least 25 percent of the original values in the manure, and a much greater loss is likely on many farms. Untimely applications and applications to low-value crops reduce the realized value still further.

The calculated value of soil fertility elements in the manure from different sizes of hog operations is shown in Table 10. Comparison of these data with the cost of saving and spreading the manure (Table 7) provides a guide as to the economy of lagoons versus storage systems.

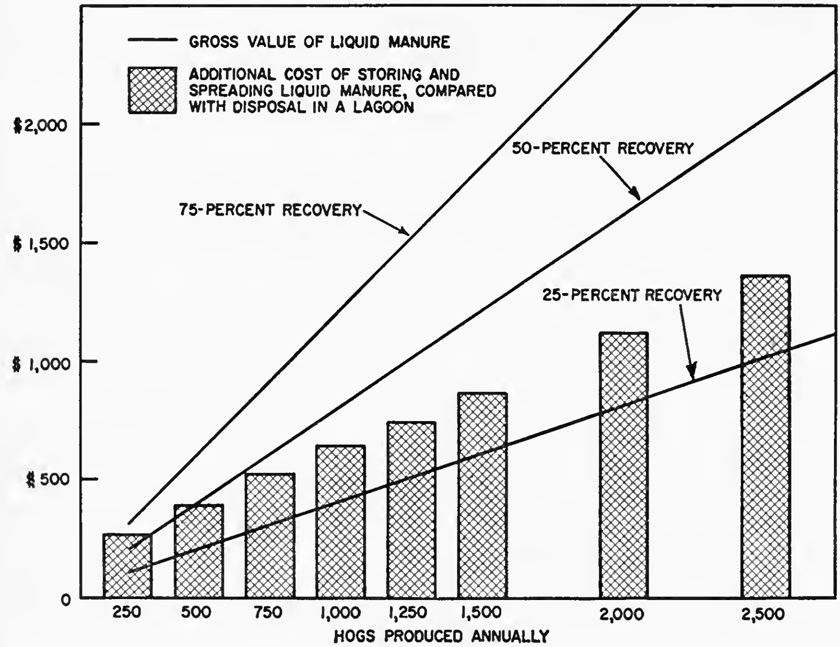
Table 10. — Calculated Value[a] of Soil Fertility Elements in Liquid Hog Manure at Specified Rates of Recovery

Hogs[c]	Value of fertility elements by percentage recovered[b]			
	100 percent initially present	At 75-percent recovery	At 50-percent recovery	At 25-percent recovery
250	$ 405	$ 304	$ 202	$ 101
500	810	608	405	202
750	1,215	911	608	304
1,000	1,620	1,215	810	405
1,250	2,025	1,519	1,012	506
1,500	2,430	1,822	1,215	608
2,000	3,240	2,430	1,620	810
2,500	$4,050	$3,038	$2,025	$1,012

[a] Based on 1960 prices for nitrogen, phosphorus, and potassium.
[b] Based on the following values for fertility elements in manure from one hog: nitrogen, $1.14; phosphorus, 33 cents; potassium, 15 cents; total value, $1.62. (See Table 9.)
[c] Market hogs grown from 50 to 220 pounds.

Two-thirds of the value of the fertility elements in manure must be saved just to cover costs in a 250-hog operation. The break-even point gradually declines to one-third of the original fertility value as annual output increases to 2,500 hogs because of economies in use of equipment and storage facilities. There will be a tendency for the break-even point to remain above this level, however, because greater hauling costs are often encountered as size of operation increases.

If a producer could achieve a 75-percent rate of recovery, storage and spreading of liquid manure would be profitable, especially for large operations (Fig. 1). High fixed costs of equipment and storage facilities cut the margin for the producer with a small output. Storage of manure for use on cropland presents almost a break-even situation if half the value of the manure is recovered. Benefits do not cover costs at any size of operation if losses are as high as three-fourths of the total. In all of these situations, spreading manure has provided the farmer with a market for his labor at $1.20 per hour.



Net cost of storing and spreading liquid hog manure compared with value of the manure at different rates of recovery for fertility constituents. (Fig. 1)

A producer should not rate himself above the 50-percent recovery mark unless he is particularly well equipped to handle manure, or has a quantitative measure (such as chemical analysis of manure, or comparative yield data) of the effectiveness of his operation. Evidence from research suggests that most producers will probably be below this level.

Other economic factors. The relative economic position of the storage method versus lagoon disposal of liquid manure may be influenced by factors other than the value of the soil fertility elements and the cost of getting them on the cropland. Among the items worth considering are: the probable imbalance of the nitrogen, phosphorus, and potassium in manure, making it necessary to supplement manure with purchased fertilizers; the possibility of reaching a buildup of plant nutrients in the soil on small farms with large livestock enterprises, to the point where additional manure gives little or no response; and compaction of the soil and damage to plants by heavy equipment during the spreading operation. Another consideration is the lessening of odors, flies, disagreeable working conditions, and unattractive appearance when manure is disposed of in a lagoon rather than stored and later spread on the land.

Summary

Confinement hog systems designed for storing liquid manure for later use on cropland present at best a break-even situation for the typical hog producer raising 500 to 750 hogs, with only a small chance that the manure is worth more than the additional costs involved in saving rather than disposing of it. The most profitable practice for the average farmer who raises hogs in confinement is to dispose of the liquid manure in a lagoon and use commercial fertilizers on his fields. This economic choice is reinforced by esthetic considerations.

These conclusions are drawn from facts observed in a 1959-1960 economic study of confinement hog production on 72 Illinois farms. Most operators in the study used bedding in their barns and removed the solid manure with tractor-powered equipment. Some farms, however, had newly-designed finishing buildings which provided for handling manure as a liquid. Manure was scraped or flushed from the feeding floor each day and carried by water to a storage tank for later use on the land, or to a lagoon for disposal.

Findings of the study indicate that the various operations involved in manure removal take about three-fourths of the total labor input used in confinment growing and finishing of hogs on the average Illinois farm. Much of this labor is used to move the manure from storage onto the land. Slotted floors in newly designed buildings offer promise for reducing the work of cleaning.

Adequate facilities for storing and spreading liquid manure consist of a cast-in-place concrete storage tank, an electrically driven auger to pump the manure from storage, and a tractor-drawn 500- to 1,000-gallon applicator tank. Calculated initial capital requirements range from around $2 per hog for equipping a unit with an annual capacity

of 2,500 head to more than $6 per hog for a 250-hog unit. Annual costs for storing, pumping, hauling, and spreading liquid manure drop from $1.28 per hog in small operations to 62 cents per hog in units producing 2,500 head annually.

Lagoons for disposing of liquid manure can be constructed on an average site for 30 to 80 cents per hog, depending upon size of operation. Lagoons have low maintenance costs, and they eliminate the expensive and disagreeable task of pumping, hauling, and spreading manure throughout the year. All of the fertility value of the manure, however, must be sacrificed to gain these cost advantages.

Fresh hog manure is a valuable source of nitrogen, phosphorus, and potassium. The quantity of these elements excreted by one hog while growing from 50 to 220 pounds is worth about $1.62 at 1960 prices for the same elements in commercial fertilizers. Producers could realize up to nearly $1 per hog above costs if they could preserve all of this fertility value and use it on crops as they would normally use commercial fertilizers.

A high proportion of the fertility value of liquid manure can be utilized if the manure is stored under anaerobic conditions, and if it is plowed under immediately after it is spread on the land. Ideal conditions, however, are seldom possible. Fertility losses, especially of the highly unstable nitrogen, begin on the feeding floor and continue while the manure is in storage and lying on the fields. Much potential value is wasted when manure must be spread on low-value crops or wasteland.

The typical producer will probably lose one-half to three-fourths of the fertility value in hog manure that is handled as a liquid. If a producer has an effective manure-handling system and thus manages to recover as much as half the original fertility value, he can pay the additional costs of storing the manure and spreading it on cropland, including a $1.20 an hour charge for labor. Some additional return may be realized in the larger operations, which afford some economies to scale in the use of equipment. If losses are greater than 50 percent, the value of the manure will not pay for the additional costs of getting it on the land.

6M—5-62—76755

UNIVERSITY OF ILLINOIS-URBANA
Q.630.7IL6B C001
BULLETIN. URBANA
676-700 1961-1964
3 0112 019528824